RIVERTON DOME GAS EXPLORATION AND STIMULATION TECHNOLOGY DEMONSTRATION, WIND RIVER BASIN, WYOMING

Fifth Quarterly Technical Progress Report

Reporting Period Start Date: October 1, 1998
Reporting Period End Date: December 31, 1998

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February 1999

D.O.E. Contract No. DE-FC26-97FT34181

Department of Energy Contracting Officer: Ms. Mary Beth Pearse

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Laramie, Wyoming 82071

Disclaimer

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Contractor Name and Address: Institute for Energy Research
University of Wyoming, P.O. Box 4068
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Date of Report February 28, 1999
Award Date: October 1, 1997
Completion Date: March 31, 1999

Government Award,
Current Fiscal Year: $1,197,989

Project Managers
& Principal Investigators: Ronald C. Surdam & Thomas L. Dunn

Reporting Period: October 1, 1998 - December 31, 1998

Objectives

This project will provide a full demonstration of an entirely new package of exploration technologies that will result in the discovery and development of significant new gas reserves now trapped in unconventional low-permeability reservoirs. This demonstration includes the field application of these technologies, prospect definition and well siting, and a test of this new strategy through wildcat drilling. In addition this project includes a demonstration of a new stimulation technology that will improve completion success in these unconventional low permeability reservoirs which are sensitive to drilling and completion damage. The work includes two test wells to be drilled by Snyder Oil Company on the Shoshone / Arapahoe Tribal Lands in the Wind River Basin. This basin is a foreland basin whose petroleum systems include Paleozoic and Cretaceous source beds and reservoirs which were buried, folded by Laramide compressional folding, and subsequently uplifted asymmetrically. The anomalous pressure boundary is also asymmetric, following differential uplift trends.

Scope of the Work

The Institute for Energy Research has taken a unique approach to building a new exploration strategy for low-permeability gas accumulations in basins characterized by anomalously pressured, compartmentalized gas accumulations. Key to this approach is the determination and three-dimensional evaluation of the pressure boundary between normal and anomalous pressure regimes, and the detection and delineation of areas of enhanced storage capacity and deliverability below this boundary. This new exploration strategy will be demonstrated in the Riverton Dome—Emigrant Demonstration Project (RDEDP) by completing the following tasks: 1) detect and delineate the anomalous pressure boundaries, 2) delineate surface lineaments, fracture and fault distribution, spacing, and orientation through remote sensing investigations, 3) characterize the internal structure of the anomalous pressured volume in the RDEDP and determine the scale of compartmentalization using produced water chemistry, 4) define the prospects and well locations as a result on this new exploration technology, and 5) utilize new completion techniques that will minimize formation damage and optimize production.

Summary of Technical Progress

Task 1. Detect and Delineate the Anomalous Pressure Boundaries Using Analysis of 2-D and 3-D Seismic Data and Sonic Log Velocity Analysis

Sonic Analysis. During the fourth quarter, we continued to work on (1) the determination and three-dimensional visualization of regional pressure surface boundaries between normal and anomalous pressure regimes, and the detection and delineation of areas with enhanced deliverability below this boundary; and (2) tests of the validity and universality of the newly developed exploration paradigm, technology, and tools specifically designed to exploit anomalously pressured, unconventional gas accumulations. The seismic velocity uncertainties have been checked. More faults and formation tops were introduced into the three dimensional anomalous velocity model. An updated three-dimensional model for the Riverton Dome 3-D survey has been constructed.

The results show that significantly anomalous velocities exist in the Frontier, Muddy, and Nugget formations (Figures 1 through 3). The existing faults have had a significant impact on the distribution of anomalous velocities. The gas-saturated areas with enhanced storage capability and deliverability below the pressure boundary surface can be nicely determined and delineated on the three-dimensional anomalous velocity model. Newly completed wells have illustrated that sections with higher initial production are characterized by intensely slow velocity anomalies (Figure 4).

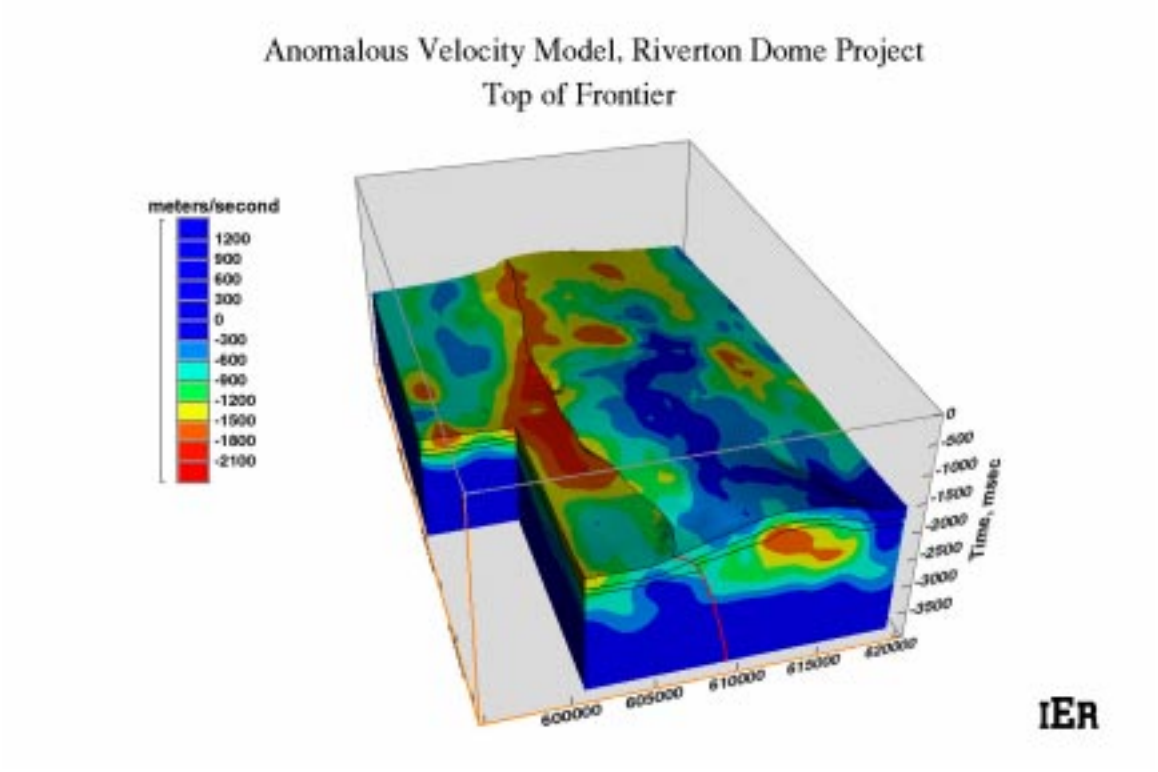


Figure 1. Anomalous velocity volume in which all the stratigraphic units above the top of the Frontier Formation have been removed. The top of the volume in this figure is the top of the Frontier Formation.

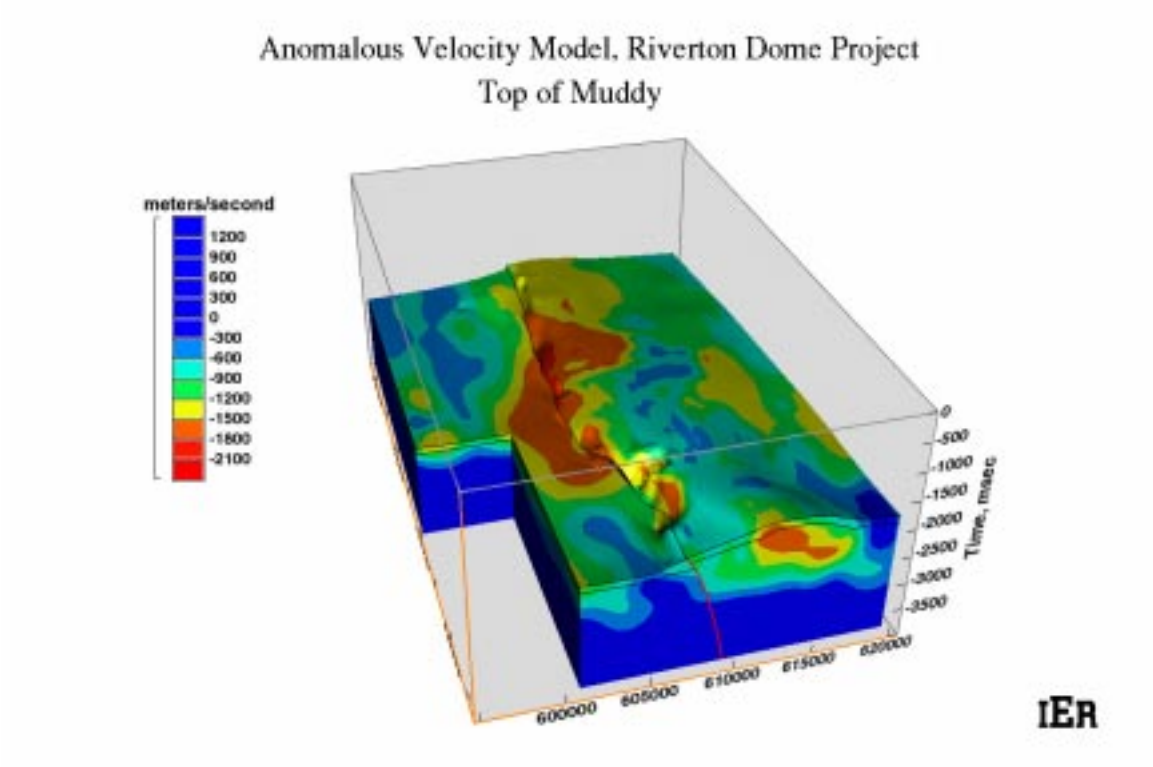


Figure 2. Anomalous velocity volume in which all the stratigraphic units above the top of the Muddy Formation have been removed. The top of the volume in this figure is the top of the Muddy Formation.

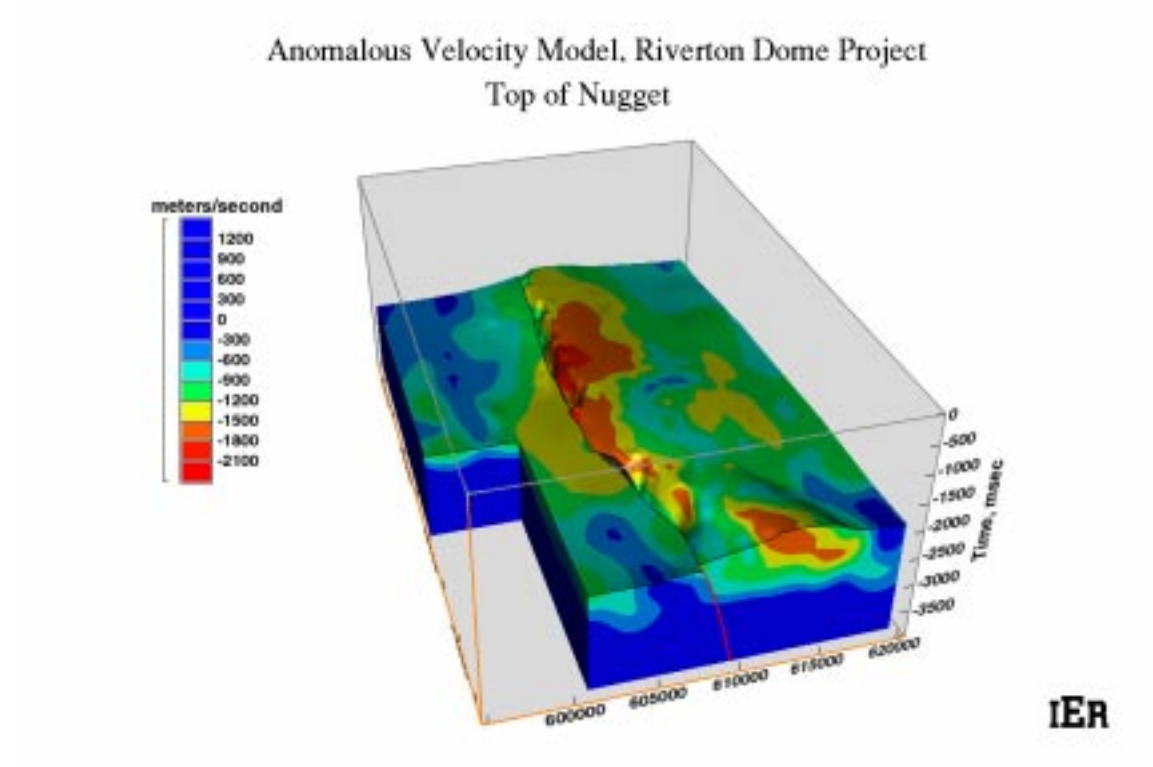


Figure 3. Anomalous velocity volume in which all the stratigraphic units above the top of the Nugget Formation have been removed. The top of the volume in this figure is the top of the Nugget Formation.

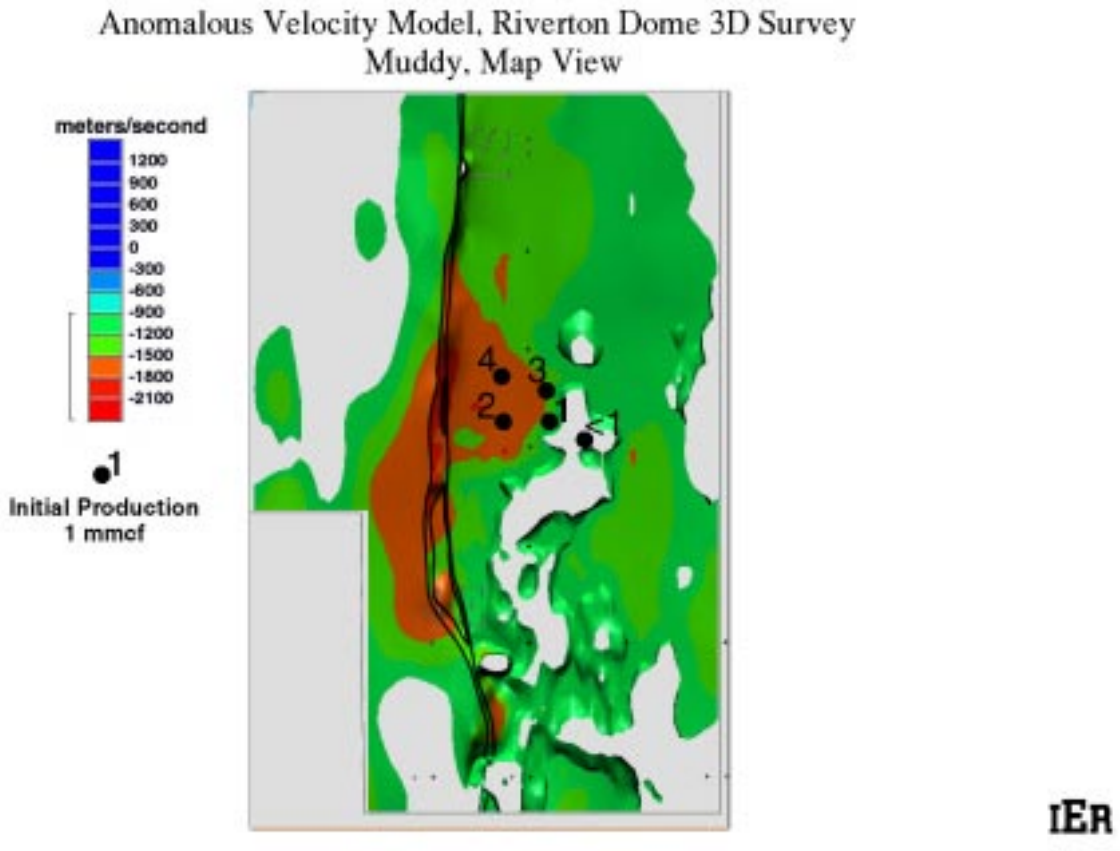


Figure 4. Map view of the top of a targeted reservoir interval, the Muddy Formation. Map is derived from a 3-D anomalous velocity volume constructed from a 3-D seismic survey in the Wind River Basin. In a blind test, five recent Muddy Formation wells are plotted on the anomalous velocity surface at the top of the Muddy Formation. The wells within the velocity anomaly (i.e., > 1500 m/s below the regional gradient) had initial high production values of two to four mmcf/day. The well at the edge of the velocity anomaly (i.e., < 1200 m/s below the regional gradient) had initial production of one mmcf/day, whereas the well drilled outside the velocity anomaly had initial production of < one mmcf/day and presently is shut in.

Seismic Analysis. We finished our detailed velocity analysis on the Riverton Dome 3-D survey. At the end, we had more than 1400 velocity functions distributed over a surface area of 40 square miles. Comparison of the interval velocity versus sonic velocity at three well locations shows our goal of achieving a good correlation between sonic and seismic velocities (Figure 5A-C). These three wells are just about the only wells in the field with sonic logs. Time-to-depth conversion was accomplished with a general function from the Wind River Basin, so there may be errors in converting the sonic log depths to time. Given the uncertainties, the correlations show that the seismically-derived velocity functions are faithful to the long wavelength form of the sonic log. In addition, we show the results of inverting the sonic velocity to stacking velocity and then superimposing this well-based stacking velocity on the semblance plots for a CDP at the well location (Figure 6A-C). In each case, the TD of the well occurs at about 1800 ms TWTT (two-way traveltime). Again, the comparison indicates a good correlation between the velocity functions.

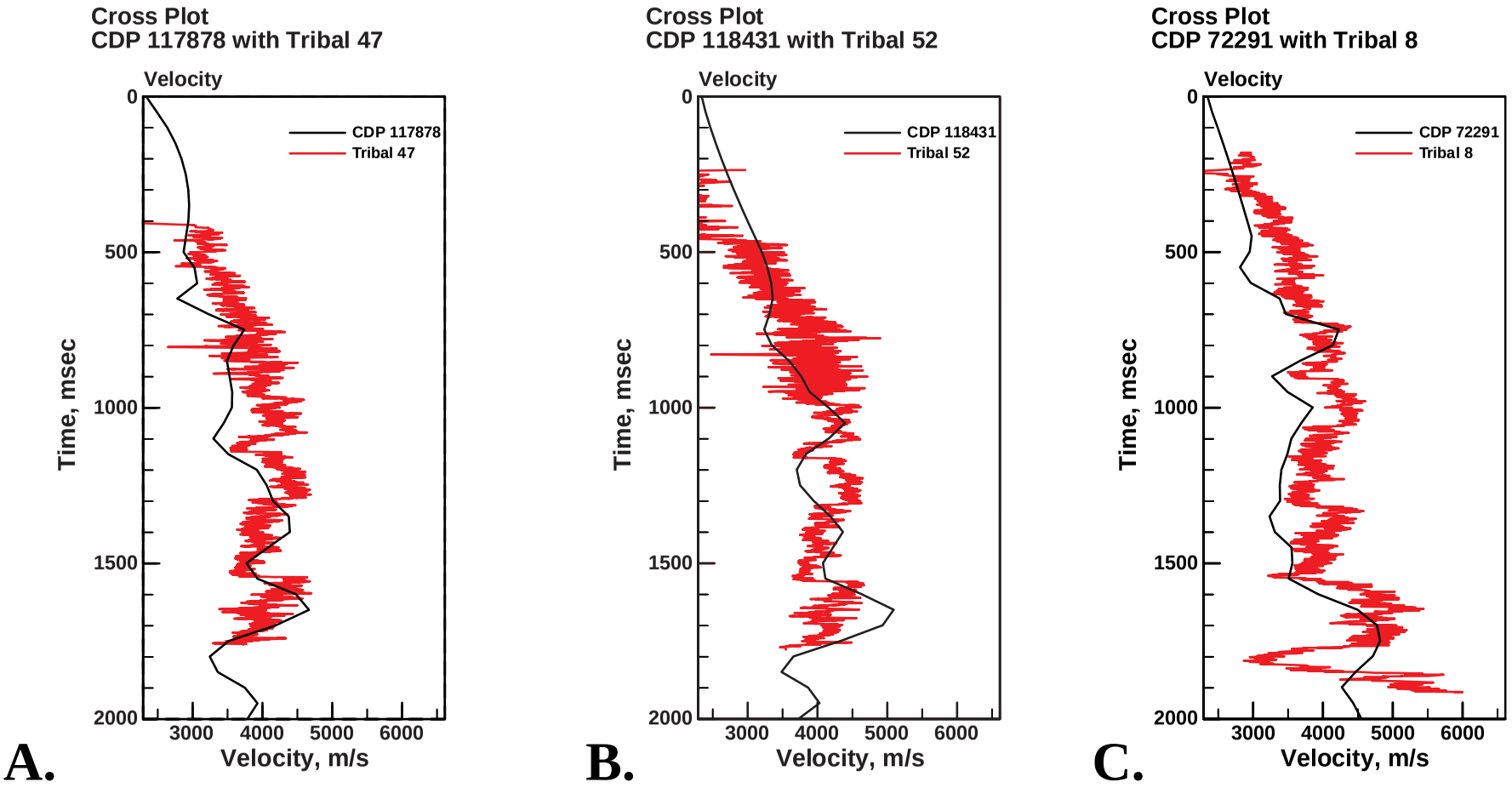
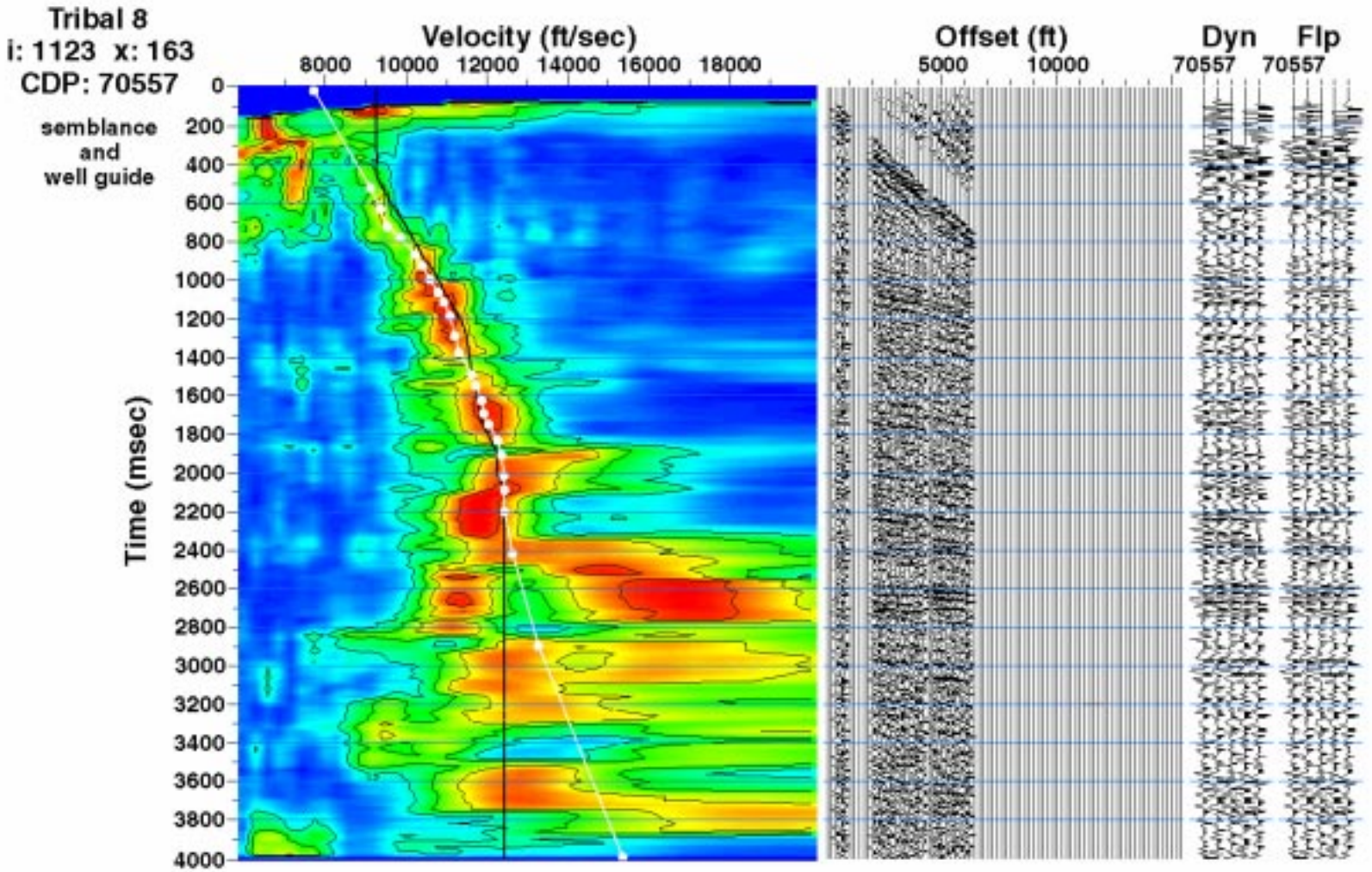


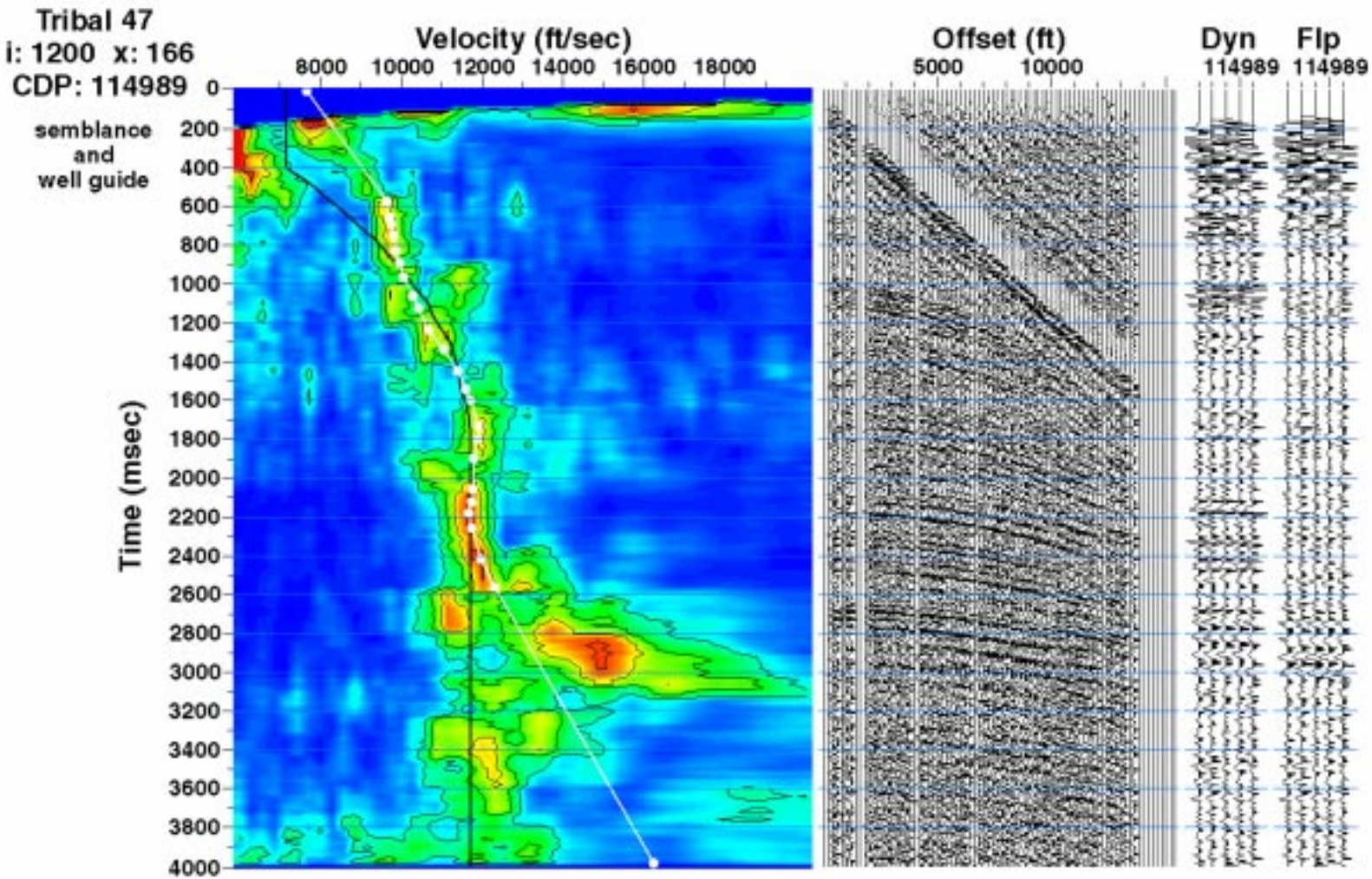
Figure 5A-C. Velocity versus traveltime; comparison of well sonic and seismic interval velocities at coincident locations. **A.** Tribal 8. **B.** Tribal 47. **C.** Tribal 52.



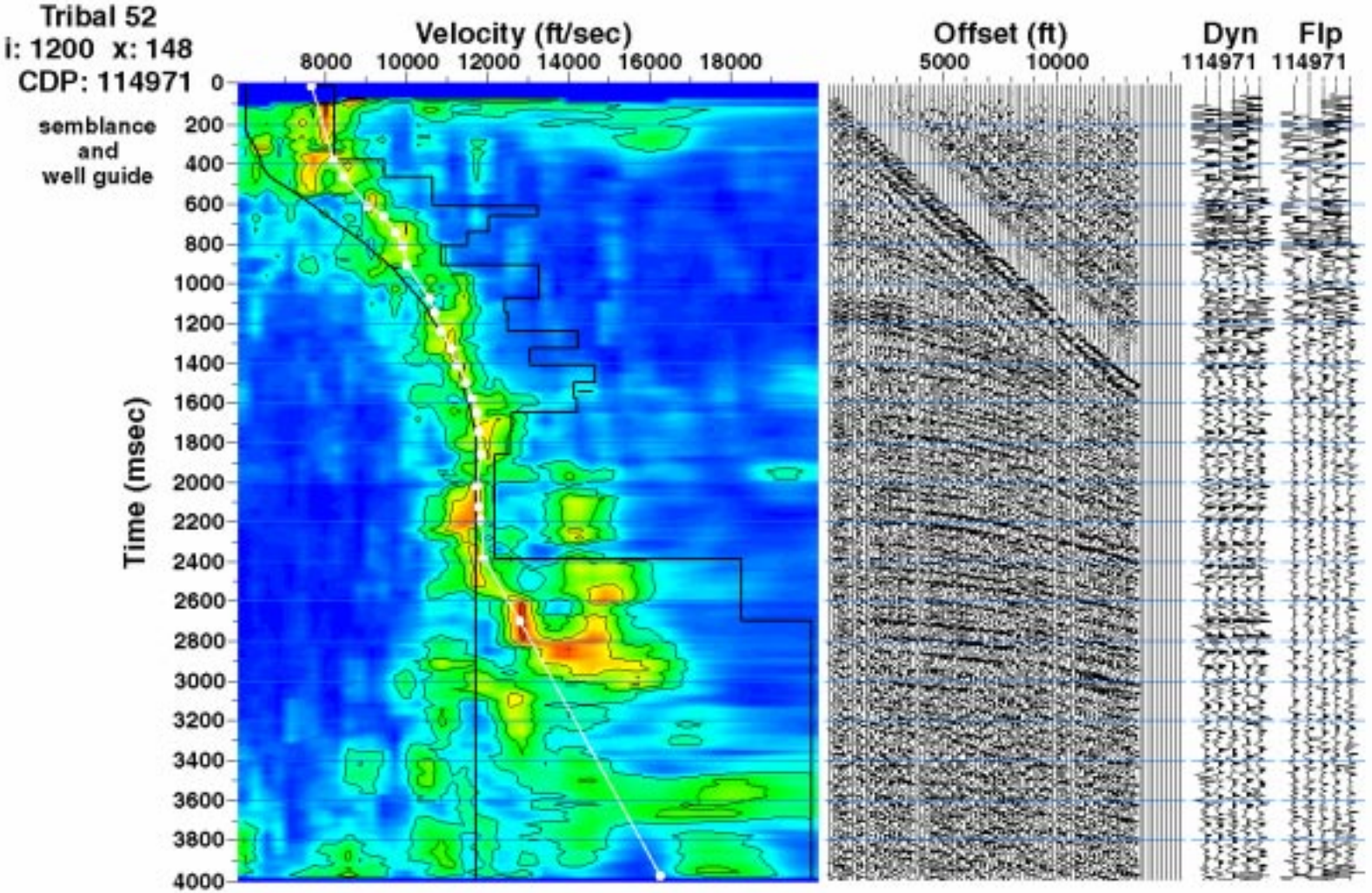
A.

Figure 6A-C. This and following two pages, traveltime-velocity-semblance plots; comparison of stacking velocity from seismic and sonic data. The black line is the function derived from inverting the sonic velocity function to stacking velocity. **A.** Tribal 8. **B.** Tribal 47. **C.** Tribal 52.

B.


Tribal 47
i: 1200 x: 166
CDP: 114989
semblance
and
well guide
Velocity (ft/sec)
8000 10000 12000 14000 16000 18000
Offset (ft)
5000 10000
Dyn
114989
Flp
114989
Time (msec)
0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 2800 3000 3200 3400 3600 3800 4000

C.


Tribal 52
i: 1200 x: 148
CDP: 114971
semblance
and
well guide
Velocity (ft/sec)
8000 10000 12000 14000 16000 18000
Time (msec)
0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 2800 3000 3200 3400 3600 3800 4000
Offset (ft)
5000 10000
Dyn
114971
Flp
114971

Task 2. Delineate Surface Fracture and Fault Distribution, Spacing, and Orientation Lineaments Through Remote Sensing Analysis

Preliminary work has demonstrated that there are several significant east-west regional linears characterizing the structural setting to the north of the 3-D seismic study area.

Task 3. Characterization of the Internal Structure of the Anomalous Pressured Volume in the RDEDP & Determination of Compartmentalization Using Produced Water Chemistry and Petrography

Seven cores have been obtained from Riverton Dome:

- Arco Mary B. O'Connor #1; 2S-4E-1
- Arco Tribal #2; 1S-4E-36
- Arco Tribal #5; 1S-4E-36
- Arco Tribal #6; 1S-5E-30
- Arco Tribal #8; 1S-5E-31
- Arco Tribal #9; 1S-5E-31
- Arco Tribal #10; 1S-4E-25

Preliminary core descriptions have been completed. A full core description, which will include interpretations of depositional environments and facies, and a fractured core description, which will include a summary of the cementation patterns within the fractures are underway for each of the seven cores obtained from Riverton Dome.

Task 4. Play and Prospect Definition and Wildcat Wells Location Determination: New Exploration Technology Demonstration

This portion of the study is of course contingent upon the above mentioned progress.

Task 5. Well Demonstrations: Exploration Technology and New Stimulation

This portion of the study is of course contingent upon the above mentioned progress and is scheduled for the latter portion of the study.

Task 6. Project Integration and Technology Transfer: Workshops, Briefings, and Publications

We have no activity to report at this time.